4.2.2.3 Exposure Assumptions for Worker Scenario

For the BHHRA, the assumptions proposed by USEPA (2002d) for an outdoor worker have generally been selected. Exposure assumptions for the worker are summarized in Table 12 and discussed below.

USEPA's (2002c) default exposure duration of 25 years for workers will be used for the RME analysis. Twelve years will be adopted to evaluate CTE estimates, based on best professional judgment. An exposure frequency of 225 days/year for outdoor workers will be used (USEPA 2002c).

Outdoor workers are assumed to be adults and mean body weight for male and female adults of 80 kg will be used (USEPA 2011b). Following USEPA (2002c) guidance, it will be assumed that a worker's head, forearms, and hands may come into contact with Site soils. Based on this assumption, a mean surface area of 3,470 cm^2 was derived. USEPA's (2004) recommended soil adherence factor of 0.2 mg/cm^2 will be adopted. This recommendation is based on data for a wide variety of activities in which an outdoor worker may engage.

Based on the assumption that outdoor workers may be involved in contact-intensive activities, the recommended soil ingestion rate for outdoor workers of 100 mg/day will be used for the RME (USEPA 2002c). Because site workers may also be involved in less intensive activities, a rate of 50 mg/day will be used to evaluate the CTE estimates. This CTE is based on the recommended rate from USEPA (2002c) for an indoor worker.

It is reasonable to assume that workers may spend the majority of their waking hours at the Site so that the daily contribution from other sources may be minimal. Thus, the fractional intake for Site soil will be assumed as 1.0 for both RME and CTE estimates.

4.3 Chemical-Specific Exposure Parameters

In addition to the scenario-specific exposure assumptions described above, there are a number of chemical specific factors that will be used to estimate $COPC_H$-specific exposure levels. These include oral bioavailability and dermal absorption factors and chemical reduction due to preparation and cooking. The chemical specific values selected for each are summarized in Table 15 and discussed below.

4.3.1 *Relative Oral Bioavailability*

Bioavailability refers to the degree to which a substance becomes available to the target tissue after administration or exposure (USEPA 2011c). Following USEPA (1989) guidance, in the absence of data to the contrary, the bioavailability of $COPC_{H}s$ will be assumed to be 1.0.

Relative bioavailability is a measure of the extent of absorption that occurs for different forms of the same chemical (e.g., lead carbonate vs. lead acetate), different vehicles (e.g., food, soil, and/or water), or different dose levels. RBA factors for oral pathways are used to account for the differences in chemical bioavailability in specific exposure media (i.e., soil, sediment, tissue) compared to the dosing vehicle used in the critical toxicity study that provides the basis for the $COPC_{H}$-specific toxicity criteria selected for use in the BHHRA.

For practical reasons, toxicity tests are usually designed using media that are expected to have high levels of bioavailability. The bioavailability of chemicals from other environmental matrices however, can be influenced by external factors such as the form of a compound (e.g., oxidation state), the length of time the chemical has been present (e.g., aging or weathering), and the physical characteristics of the medium (e.g., fraction of organic carbon in soil/sediment). It can also be influenced by internal biological factors such as absorption mechanisms within a living organism.

The relative bioavailability of a chemical in an environmental medium (e.g., soil, sediment, tissue) can be expressed as:

$$RBA = \frac{absorbed\ fraction\ from\ exposure\ medium\ on\ site}{absorbed\ fraction\ from\ dosing\ medium\ used\ in\ toxicity\ study} X\ 100 \qquad \text{(eq. 4-5)}$$

Literature searches were conducted to identify appropriate RBA values for $COPC_{H}s$ that are anticipated to be risk drivers for the BHHRA for soil, sediment, and tissue. No information was available with which to quantify RBA_{tissue}. Thus, in all cases, the RBA_{tissue} will be assumed to be 1.0, or 100 percent. The relative bioavailability of COPC$_{HS}$ in soils and sediments is discussed below.

The RBAs shown in Table 15 will be applied in the BHHRA. Uncertainties associated with the RBAs will be discussed in the uncertainty analysis of the BHHRA.

4.3.2 *Relative Bioavailability of Chemicals in Soils and Sediments*

Although relative bioavailability may differ between sediment and soil, existing data are currently insufficient to determine default RBAs for sediment. In the absence of site-specific information on bioavailability of sediment, USEPA and the Interstate and Technology Regulatory Council recommend that default factors for soil be adopted to evaluate sediment exposures (USEPA 2004; ITRC 2011).

Sufficient data with which to evaluate RBA$_{soil–sediment}$ were available for dioxins and furans and for arsenic. The RBA$_{soil–sediment}$ for each of these COPC$_{HS}$ is discussed below. A conservative default RBA$_{soil–sediment}$ value of 1.0 will be assumed for the remainder of the COPC$_{HS}$ including cadmium, chromium, copper, mercury, nickel, thallium, PCBs, and BEHP. The uncertainty associated with the RBAs selected will be discussed in the uncertainty evaluation to be included in the BHHRA. The impact of alternative assumptions may be quantified for risk-driving COPC$_{HS}$ in soil and sediment.

4.3.2.1 Dioxins/Furans

USEPA (2010c) acknowledges that the relative bioavailability of dioxins and dioxin-like compounds in soils is less than 100 percent. In the Final Report, *Bioavailability of Dioxins and Dioxin-Like Compounds in Soil* USEPA (2010c), USEPA identified six studies that reported a total of 17 RBA test results for 2,3,7,8-TCDD in soil and sediment at concentrations ranging from 1.9 to 2,300 ng/g. The selected studies provided RBA estimates in test materials consisting of soil and sediment contaminated with dioxins *in situ*. The RBA for these studies ranges from less than 1 to 49 percent. Studies of spiked soil materials were not included in the analysis because aging of contaminated soil may decrease the bioavailability of dioxins in soil.

The high end of the soil and sediment concentrations of 2,3,7,8-TCDD and TEQ_{DF} at the Site are within the range included in USEPA's review. Based on these data, an $RBA_{soil-sediment}$ of 0.5 will be applied for TEQ_{DF} in the BHHRA.

4.3.2.2 Arsenic

The relative bioavailability of inorganic arsenic in soil can vary due to differences in geochemical parameters and absorption mechanisms in receptor species. Several meta-analyses of arsenic bioavailability are available:

- USEPA (2010d) completed *in vivo* tests of 29 test materials from contaminated arsenic and clean sites using the Juvenile Swine Model. The test materials represented a large variety of arsenic phases (e.g., oxides, sulfates, phosphates). Discounting three tests that were determined to be unreliable due to levels of administered arsenic, estimated RBA values ranged from less than 10 to 61 percent with a mean of 34 percent Based on these findings USEPA Region 8 concluded that an RBA of 0.50 as a generally conservative default value for inorganic arsenic (USEPA 2011d).
- Bioavailability studies conducted by Roberts et al. (2007) in cynomolgus monkeys measured the bioavailability of arsenic in 14 soil samples from 12 different sites, including mining and smelting sites, pesticide facilities, cattle dip vat soil, and chemical plant soil. The reported RBAs ranged from 5 to 31 percent.

Based on the available information, an $RBA_{soil-sediment}$ of 0.50 will be used in evaluating oral exposures to soil and sediment in the BHHRA.

4.3.3 *Dermal Absorption Factor for Soil and Sediment*

The dermal absorption factor represents the proportion of a chemical that is absorbed across the skin from the soil and/or sediment matrix once contacted. Skin permeability is related to the solubility or strength of binding of the chemical in the soil or sediment matrix compared to the skin's *stratum corneum*. Therefore, dermal absorption is dependent on the properties of the chemical itself, as well as external factors including the physical properties of the soil or sediment matrix (e.g., particle size and organic carbon content) and the conditions of the skin (e.g., skin condition, moisture content).

Table 15
Summary of Chemical-Specific Exposure Parameters

$COPC_H$	Dermal Absorption Factor for Soil/Sediment (ABSd) (% as fraction)		Relative Soil / Sediment Bioavailability Adjustment (RBA_{ss}) (% as fraction)		Relative Food Bioavailability Adjustment (RBA_{tissue}) (% as fraction)		Chemical Reduction Due to Preparation and Cooking (LOSS) (% as fraction)	
Dioxins/Furans								
Dioxins and Furans	0.03	a	0.5	b	1	d	0	d
Metals								
Arsenic (inorganic)	0.03	a	0.5	b	1	d	0	d
Cadmium	0.001	a	1	d	1	d	0	d
Chromium	0.02	c	1	d	1	d	0	d
Copper	1	d	1	d	1	d	0	d
Mercury	0.03	c	1	d	1	d	0	d
Nickel	0.04	c	1	d	1	d	0	d
Thallium	1	d	1	d	--		--	
Zinc	1	d	1	d	1	d	0	d
Polychlorinated Biphenyls								
Polychlorinated Biphenyls	0.14	a	1	d	1	d	0	d
Semivolatile Organic Compounds								
Bis(2-ethylhexyl)phthalate	0.1	a	1	d	1	d	0	d

Notes

-- = Not applicable; not a $COPC_H$ in this medium.
$COPC_H$ = chemical of potential concern to be addressed in the baseline human health risk assessment

a - Value is from USEPA (2004).
b - Multiple sources were used to derive this value (see Section 4.3.2 of text).
c - Value is from CalEPA (2011).
d - Conservative default assumption.